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14. ABSTRACT
Modern gas turbine engines (Figure 1) used in military fighter jets depend on nickel-based super alloys for their critical components due to their ability to withstand high combustion temperatures. However, the very characteristics providing good high temperature strength in these alloys make them difficult to machine efficiently by limiting the speed capability of the cutting tools. A joint effort between the NCDMM and alliance partner Kennametal, Inc. involved developing an advanced coated carbide cutting tool for turning nickel-based alloys such as Inconel 718 with 40% higher machining productivity.

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Development of Advanced Carbide for Nickel-Based Alloy Machining for Turbine Engines

NCDMM Project No. 05-0078-10

Technical Report

PROBLEM / OBJECTIVE

Modern gas turbine engines (Figure 1) used in military fighter jets depend on nickel-based super alloys for their critical components due to their ability to withstand high combustion temperatures. However, the very characteristics providing good high temperature strength in these alloys make them difficult to machine efficiently by limiting the speed capability of the cutting tools.

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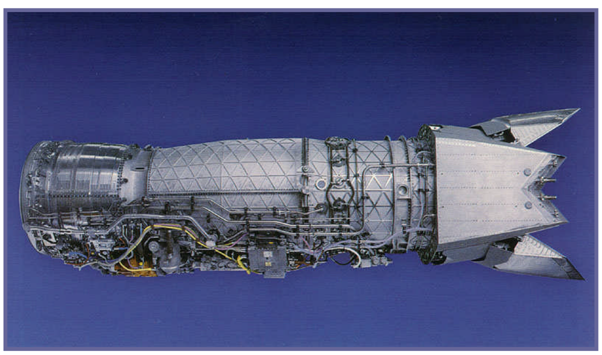

Figure 1: F-22 Raptor // F-119PW 100 Turbine Engine

ACCOMPLISHMENTS / PAYOFF

Process Improvement

Based on a field survey, general purpose machining of aircraft engine parts (nickel-based alloys) is generally done with carbide tools at 180 surface feet per minute (SFM), 0.008 inches per revolution (IPR), and 0.030-inch depth of cut (DOC). To achieve a 40% improvement in metal removal rate (MRR), the machining speed was raised to 250 SFM while keeping the feed (IPR) and DOC constant for the project. Benchmark testing of six (6) cutting tools from various companies at 180 and 250 SFM led to the establishment of a tool performance goal. It was seen that rapid nose wear resulting from premature coating flaking limits tool life in Inconel machining.

Implementation and Technology Transfer

After numerous Design of Experiments (DOE) on substrate, coating and tool geometry, optimized design features of the insert were identified and the projected goal of a 40% increase in machining productivity with acceptable tool life was achieved.

It was shown that the substrate and insert geometry had the greatest impact on tool life. Additional performance enhancement could be obtained through the correct choice of coating.

The best tool life was achieved using a straight WC-Co grade with a Nano PVD AlTiN coating. The tool utilized a chipbreaker style indexable insert containing a -MS designation (Chipbreaker geometries are identified with different designations depending on the dimensions of the chip grooves that are molded into the surfaces of indexable carbide inserts). A WC-Co-TaC substrate with PVD AlTiN coating in either -MS or -UP chipbreaker designations also showed good tool life.

With PVD AlTiN coating, the WC-Co-TaC substrate was superior to the straight WC-Co grade and the –UP geometry was superior to the –MS geometry. Finally, a direct correlation was obtained between hone size and tool life with 0.0015 inch as the preferred nominal hone size.

Expected Benefits

The outcome of the project resulted in the development of a cutting tool capable of a 40% increase in productivity with acceptable tool life while machining nickel-based alloys such as Inconel.

TIME LINE / MILESTONE

Start Date..September 05
End Date..June 06

PROJECT FUNDING

NCDMM Funding...$150K

PARTICIPANTS

Kennametal Inc.
NCDMM

For additional information concerning this project, contact the NCDMM at www.ncdmm.org